Photonics and Laser Technology Program

Anca L. Sala and Ellis Love
College of Engineering
Baker College
Flint, MI 48507
Email: anca.sala@baker.edu

Abstract

Light-based technologies continue to develop at a fast pace, and have a large and beneficial impact on the world's economy. This is due to photonics being an enabling technology, used extensively in multiple sectors such as manufacturing, defense and homeland security, medicine and health, communications, and energy. Year 2015 was declared the International Year of Light by UNESCO and was celebrated with events in more than 100 countries. In the Midwest, photonics and especially high-power lasers play an important role in manufacturing and defense industries. Well prepared technicians are in high demand by the photonics companies to support the growth of the industry. These technicians are however quite difficult to find, as there are few programs across the US who prepare them. Our school started a photonics and laser technology program four years ago with support from the National Science Foundation (NSF). The program is very hands-on with experimental lab components in virtually all core courses. A well-equipped Optics and Photonics Laboratory has been created, which continues to grow with additional equipment. The program culminates with a capstone project where students put together a laser-based optical system. The program curriculum is continuously revised and improved under guidance from an Industrial Advisory Board. New applications such as the use of LIDAR in autonomous vehicles and others are planned for introduction in the curriculum next academic year. Graduates of the 2-year program can continue their education with a 4-year engineering or engineering technology program. The paper will present the photonics and laser technology program curriculum, laboratory resources, capstone projects, and program related activities.

Introduction

Michigan is known everywhere for its dominant automotive industry. The state however also has a vested interest in other industries and diversifying its economy. Photonics is a less known industry in the state, although built on a solid foundation of many contributions from well known researchers at the flagship universities in the state. Globally, photonics is poised to grow from 530 billion USD in 2017 to 800 billion USD by 2022[1]. The photonics industry in Michigan is also expanding, due to the explosive growth of applications such as laser material processing in manufacturing and others. At the end of 2012 several photonics companies and academic institutions in the state came together to form the Mi-Light Michigan Photonics Cluster[2]. The non-profit organization recognized workforce development as a key element in the growth of the industry and pledged to support educational programs that prepare photonics workers.

The two-year Photonics and Laser Technology program was introduced at Baker College in fall 2013. The program was validated by a research study guided by OP-TEC[3], the NSF supported National Center for Optics and Photonics Education, and Mi-Light. Baker College also applied for an NSF Advanced Technological Education (ATE) Project Grant to support the development and introduction of the program, which it received in summer 2013. The grant was instrumental for the development of the program curriculum, the creation of the Optics and Photonics Laboratory, and outreach activities.

Program curriculum

The two-year Photonics and Laser Technology program focuses on providing students with knowledge of the fundamental principles of lasers and other optical devices, coupled with strong hands-on laboratory and experimental skills. The curriculum is built on a foundation of general education, mathematics up to pre-calculus, and college physics courses. The optics and photonics core of the program is supplemented by several courses in electrical technology, robotics, and Computer Aided Design to provide a well-rounded education to a technician working in the photonics field.

The program as initiated in fall 2013 included 105 credit hours in quarter format, or 70 semester hours. In fall 2017 Baker College transitioned to a semester calendar, which provided an excellent opportunity to review and revise all programs. The College decided to standardize all bachelor programs to 120 credits and associate programs to 60 credits in semester format. A student enrolled full-time in an associate program can thus complete the program in four semesters or two years. The Photonics and Laser Technology program was revised from the initial 70 semester credits to 60 semester credits in fall 2017.

Table 1 compares the program curriculum in quarter system vs. semester system. Courses with an L after the name include a laboratory component. Even though the number of credits was reduced in the transition to semesters, the program maintained its rigor and depth. Some of the credit reductions came from the general education area, while others came from core courses. For example, Geometric Optics and Wave Optics were separate courses in the curriculum. In the semester version these courses were eliminated, but a lot of their content was added to the Introduction to Photonics and Lasers course, which became a 4-semester credit course. The Robotics course was added to the curriculum in semester version. This is needed due to the use of robots together with high power lasers in manufacturing.

Table 1. Photonics and Laser Technology program curriculum in quarter and semester versions

Quarter System (Fall 2013 - Summer 17)		**Semester System (Fall 2017 - Present)**	
Course Name	**Credits**	**Course Name**	**Credits**
EET 111 Electrical Technology (L)	4	CAD 2260/CAD 2310/CAD2360 CAD course selection (L)	3
EET 115 DC Circuits (L)	4	ECN 2010/ECN 2110/PSY 1010/PSY 1110 General Education selection	3
EET 125 AC Circuits (L)	4	EET 1110 Electrical Technology (L)	4
EET 136 Digital Circuits I	4	EET 1150 Circuits (L)	4
EET 211 Solid State Devices I (L)	4	EET 1610 Introduction to Robotics (L)	3
EET 221 Fiber Optics and Data Communications (L)	4	ENG 1010 College Composition I	3
EET 251 Introduction to Photonics and Laser Technologies (L)	4	ENG 1020 College Composition II	3

EGR 111 Technical Communications for Engineering Sciences	4	MTH 1110 College Algebra I	3
ENG 101 Composition I	4	MTH 1310 Pre-Calculus	5
ENG 102 Composition II	4	PLT 1210 Introduction to Photonics and Lasers (L)	4
ME 107 Introduction to 3-D Modeling	4	PLT 2310 Optical Components, Systems and Metrology (L)	3
MTH 111 Introductory Algebra	4	PLT 2350 Fiber Optics and Data Communications (L)	3
MTH 112 College Algebra	4	PLT 2410 Laser Systems (L)	4
MTH 124 Trigonometry	4	PLT 2510 Photonics Applications	3
PLT 211 Geometrical Optics (L)	4	PLT 2710 Capstone Project	3
PLT 221 Wave Optics (L)	4	SCI 2150 Integrated Physics (L)	3
PLT 231 Laser Fundamentals (L)	4	SPK 2010 Oral Communication	3
PLT 235 Laser Systems (L)	4	WRKTC 2010 Work Experience I	3
PLT 241 Optical Systems Analysis (L)	4		
PLT 251 Photonics Applications	4		
PLT 271 Capstone Project	4		
PSY 101 Human Relations	4		
SCI 215 Integrated Physics (L)	4		
SPK 201 Oral Communication	4		
WRI 115 Workplace Communication	4		
WRK 291 Professional Career Strategies	1		
WRKTC 201 Work Experience	4		
Total credits	**105**	**Total credits**	**60**

Courses PLT 1210, PLT 2310, PLT 2410 and a portion of PLT 2510 use textbooks created by OP-TEC specifically for photonics technician education. These materials are fairly unique, as the vast majority of textbooks on photonics and lasers available from traditional publishers are written at a higher level, suitable for senior undergraduate and graduate education.

As is the case with advanced technologies, photonics technology progresses rapidly. New applications continue to be developed and implemented. LIDAR, the light detection and ranging device that uses lasers to create terrain maps, is one of the photonics applications which will feature prominently in autonomous vehicles. In summer 2017 Baker College received a second NSF ATE Project grant to support the expansion of the Photonics program and update its curriculum. Curriculum additions will include autonomous vehicle sensors, laser material processing, and integrated photonics. These will be incorporated in the Photonics Applications and Capstone Project courses.

The Industrial Advisory Board (IAB) plays an important role in reviewing and approving the program curriculum, to ensure the program provides students with the appropriate knowledge and skills and maintains its currency. The IAB includes representatives from several photonics companies as well as Mi-Light. The IAB reviewed the semester version of the program and approved it.

Optics and Photonics Laboratory

Preparing students with hands-on laboratory skills to complement their theoretical knowledge is of utmost importance in a program focused on technology. A dedicated Optics and Photonics Laboratory was created when the Photonics and Laser Technology program was introduced. Initially the lab was equipped with the parts necessary to teach the Introduction to Photonics and Lasers course. Mostly these consisted of the commercially available Optics Education Kits from Newport (OEK-STD). Each kit includes mirrors, lenses and related components, mounts, a 2'x2' optical breadboard, a Helium-Neon laser, and an optical power meter and detector. As the program progressed to the upper level photonics courses, different lasers and test equipment were added. Lasers available in the lab include Helium-Neon lasers, diode lasers, Argon ion lasers, Nd:YAG lasers, and fiber lasers. A CO_2 laser is available as part of a laser cutter/ engraver. The lasers range in power from a few mW to 400 W for one of the fiber lasers. Test equipment includes power and wavelength meters, spectrometers, interferometers, and beam profilers.

Fig. 1 Students working in the Optics and Photonics Laboratory.

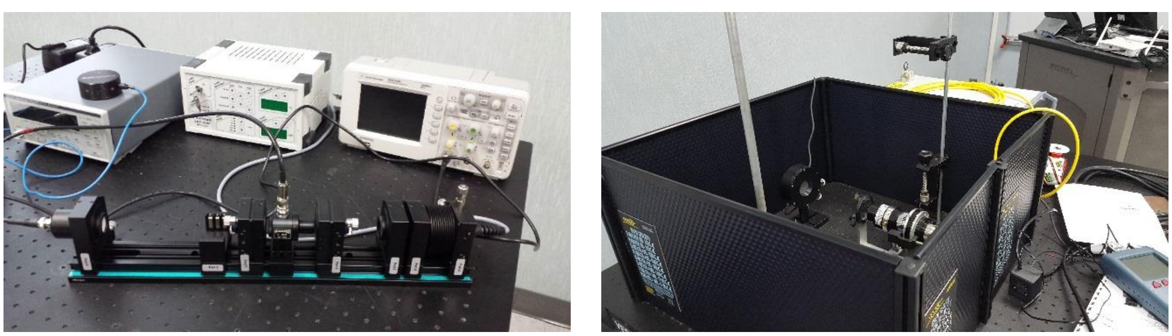

Fig. 2 Left: Nd:YAG laser having an open structure that allows students to learn and practice laser alignment; Right: 400 W fiber laser and high power detector.

The Capstone Project course takes place during the last semester of the program. The course guides students to use the knowledge and hands-on skills acquired throughout the program to build and demonstrate a laser/electro-optic system. Student projects to date included laser engraving using the 400 W fiber laser, a laser projector, and even an optical Theremin.

A more recent acquisition for the lab was equipment for teaching optical waveguides and integrated photonics applications. Experiments using the equipment include investigation of step index and graded index waveguides, Bragg gratings, and Wavelength Division Multiplexing. These topics will be introduced in the curriculum in the next academic year.

We are also currently building a second laboratory, for advanced laser applications. The new lab will house a 1 kW fiber laser attached to a robot and will be used to teach laser materials processing. The lab will be used by college students doing their Capstone Project and will also be available for visits and collaborations with outside groups.

Fig. 3 High power (1 kW) laser for advanced laser applications.

Outreach activities

Photonics as an advanced technology and an excellent career field are largely unknown to the public, despite the ubiquitous nature of photonics applications in every day life. This lack of awareness makes it difficult to attract sufficient numbers of students to programs such as the one described above. To increase awareness about optics and photonics, outreach activities must be an integral part of the program deployment. Since the Photonics and Laser Technology program started at Baker College in 2013 we have engaged in numerous such activities, including visits and presentations at Career Days at middle and high schools, hosting high school visits to our Optics and Photonics Lab, summer camps for middle and high school students, participation in large public events such as the “Back-to-the-Bricks” car show and others. The activities that took place during 2015 had a special focus as that year was designated as the International Year of Light (IYL) by UNESCO. More details about IYL celebration can be found in reference [4].

Fig. 4. “Back-to-the-Bricks” 2017 optics and photonics outreach participants.

An important feature we strive to incorporate in all outreach activities is interactivity. It is well known that lecture only college courses result in less engagement from students and less retention of the material. Similarly, outreach activities based on simple power point presentations are less successful than ones which include hands-on portions for the participants. The kits of parts we make available to participants during outreach activities include: red and green laser pointers, photometer to measure the optical power of the lasers, laser safety glasses, color filters, diffraction gratings (handheld spectrometers/diffraction glasses), prisms, plastic optical fibers, and LEDs in various configurations. We explain the optical phenomena involved and demonstrate them in practice, before encouraging students to experiment with the parts.

The most recent addition to the demo kits is a hobby LIDAR device from Scanse. The device is based on a time of flight ranging method to determine the distance to objects in a plane. It uses a class 1 laser diode emitting at 905 nm. The beam rotates around one axis. By mounting the device on a rotating base, it is possible to add a second axis of rotation and create a 3D map of the environment. Outreach activity participants have provided positive feedback on the LIDAR demonstrations. In general, what students appreciate the most is seeing advanced optics and laser applications, as they are always wondering where something is applied, rather than learning only the fundamental principles. LIDAR will be part of an educational module on optical sensors for autonomous vehicles that will be introduced in the Photonics program curriculum as part of the PLT 2510 Photonics Applications course.

As part of the recent NSF grant received by the program, we have also started working on introducing photonics content in some Career and Technical Education (CTE) programs taught in Michigan. Targeted CTE programs include Mechatronics, and Engineering Technology. The topical areas covered by these programs can be naturally expanded to include photonics and laser technology. In previous years we have conducted workshops for high school teachers to introduce them to photonics. Several photonics lessons were taught during the workshops using Light and Laser kits from LASER-TEC[5], the Southeast Regional Center for Laser and Fiber Optics Education. At the conclusion of the workshop teachers received the kits to take with them to facilitate the introduction of photonics in their classes. A photonics workshop will once again be offered to teachers in late spring 2018.

Conclusions

The Photonics and Laser Technology program at Baker College teaches students to build, test, calibrate, and maintain laser and electro-optic devices and systems that generate, transmit, and manipulate light. The program is one of the few two-year programs for photonics technicians throughout the Unites States and the only one in Michigan. The well-rounded program curriculum focuses on optics and photonics courses, and also includes introductory electronics, robotics, and Computer Aided Design courses. Most courses include lab components to provide students with essential hands-on skills in laser and optical device handling. Outreach activities are an integral part of the program. Current efforts are directed towards the introduction of photonics content in some Career and Technical Education programs in the state.

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